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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services To: The Commission	)	Gen. Docket No. 90-314 File No. PP 27

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FURTHER SUPPLEMENT TO REQUEST FOR PIONEER'S PREFERENCE AND SIXTH QUARTERLY REPORT

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Summary

Time Warner Telecommunications, a division of Time Warner Entertainment, L.P. has been an industry leader in defining Personal Communications Services ("PCS"), in working with the Executive Branch and Congress on the exciting possibilities for PCS in the U.S., and in defining the technologies critical to the launch of our domestic PCS industry.

Time Warner believes that a PCS product should permit users to take one handset from home to office, from the neighborhood to their cars on cross-country drives. This product should be offered to the broadest range of consumers at the most affordable price.

Thus, in its test program, Time Warner has studied those technical areas most likely to influence the cost-effectiveness of system infrastructure and consumer handsets.

Based on its experiments to date, Time Warner believes that the integration of cable television and PCS systems can result in substantial savings in infrastructure. One means of achieving such savings through integration is by centralizing much of a PCS base station circuitry at a cable TV head end and using cable television lines to bring the station's coverage to all areas through so-called "remote antennas". Time Warner was the first company to test the remote antenna concept on active cable plant in the U.S.

A second method of integration is using cable TV capacity to support digital communications circuits which link remote base

stations with a PCS system's switching and control facilities. Time Warner has also tested this concept on its futuristic 150 channel Quantum Cable TV system serving portions of Queens, New York.

On the handset side, a crucial issue is the behavior of 2 GHz channel as compared to other frequencies for which handsets are commercially available. Time Warner has performed extensive propagation studies to gather the path loss and delay spread data which will be critical inputs to the design of consumer hardware.

Time Warner's innovative proposal to combine fiber-trunked cable television plant with an integrated radio overlay in the 2 GHz band will allow the provision of new personal communications services in the pioneering manner envisioned by the Commission. Based on its experiments with remote antenna systems and digital carrier transport systems using existing "live" cable television facilities and its signal propagation studies, Time Warner has established that it is entitled to a pioneer's preference in the PCS licensing process under the standards for a preference established by the FCC.

Specifically, Time Warner's pioneering integration of PCS and cable television systems adds functionality to existing and future cable television facilities. In addition, Time Warner's PCS proposals offer a cost-effective means of employing lower power PCS base stations, thus affording new wireless stations to share 2 GHz spectrum more effectively with fixed microwave users in the transition plan through the use of excess cable television capacity. Furthermore, Time Warner's PCS system design can reduce costs to the public by using both the remote antenna and digital carrier transport systems to introduce PCS services without incurring prohibitive start-up costs. Finally, Time Warner's PCS system concept makes a new or different use of the spectrum by combining state-of-the art cable television facilities with a new and different use of the 2 GHz spectrum band to create an entirely new mobile communications service. Accordingly, the Commission should award Time Warner a PCS licensing preference for the New York City area based on its pioneering work.

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Further Supplement to Request for Pioneer Preference and Sixth Quarterly Report of PCS Experimental Work

Time Warner Telecommunications[1] ("Time Warner"), by its attorneys, hereby submits supplemental comments in the above-captioned proceeding.[2]

I. INTRODUCTION

Time Warner has been an industry leader in defining Personal Communications Services (PCS), in working with the Executive Branch and the Congress to see the exciting possibilities for PCS in the U.S., and in defining the technologies important to the launch of PCS.

Time Warner has sought, through on-going PCS trials,[3] to bring to fruition a PCS product to be used in the home or office, on the street, and in a mobile environment. The company intends to offer this product to the broadest range of consumers at the most affordable price.

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1 Time Warner Telecommunications is a division of Time Warner Entertainment L.P.

2 The body of these comments is being filed simultaneously herewith in the form of a "Sixth Quarterly Report of PCS Experimental Work" as required by the terms of the experimental license referenced in footnote 3, below.

3 Time Warner has received experimental authority for PCS testing using various frequency bands at locations in and around New York City, NY (KF2XHP), Cincinnati, OH (KF2XHR), Columbus, OH (KF2XHS) and St. Petersburg, FL (KF2XHQ).

Affordability will depend predominantly on infrastructure and customer equipment costs. As a result, Time Warner's test program has focused on two areas in which greater research can result in lower costs: studying the suitability of 2 GHz and other frequency bands for wireless services (and the concomitant adaptability of existing technology and practice to 2 GHz uses); and assessing the technical aspects of integrating cable television and PCS systems to lower infrastructure expense. In addition, given that wireless office communications will constitute one important element of PCS use, Time Warner has also recently begun technical and user wireless office trials with the goal of integrating this application into the cable/PCS infrastructure in order to provide "seamless" PCS capability from home to office and beyond.

During the past quarter, the company has concentrated much of its efforts in more fully understanding the basic propagation characteristics of the 2 GHz band that has now been identified as the future home of PCS and comparing these with the characteristics found at frequencies near today's cellular allocation. This work has been done to develop the basic technical information underlying 2 GHz radio communications which Time Warner believes must be one of the key starting points in the design of PCS systems. The fruits of these labors are the necessary groundwork to answer many fundamental questions related to the usefulness of particular PCS radio technologies, system architectures and telecommunications services.

Additionally during this quarter, Time Warner has expanded on its past work in introducing and refining means of integrating cable television and PCS systems. Moreover, the company has inaugurated exploration of the technological and productivity-enhancing facets of wireless office systems.

II. SUMMARY OF PREVIOUS EXPERIMENTAL WORK

Time Warner envisions PCS as an array of mass market, consumer friendly communications applications and services. To achieve mass market acceptance, however, equipment and service prices (and costs) must be kept at a level competitive with wireline services. Time Warner requested experimental authority so that it could investigate those areas which are most likely to help minimize PCS costs and prices -- propagation characteristics and the cost-effective integration of PCS and cable television infrastructure -- as well as gain familiarity with the technical and user value of various PCS access technologies and applications. Time Warner's experimental activity and results, detailed in the company's quarterly reports to the Commission, are summarized briefly below.

A. Fall 1991

Preliminary propagation tests were conducted in downtown Manhattan at 2.4, 5.8, 12.9 and 18.4 GHz. Among other things, the results of these tests provided both empirical data to complement the analytical planning that Time Warner was conducting for more comprehensive propagation measurements and an initial evaluation of the suitability of the two CARS bands for various wireless applications. This work was followed by the development of a plan for conducting a set of comprehensive propagation tests.

B. Winter 1992

Long lead time equipment required for the propagation tests was ordered. Additionally, a plan for testing the integration of cable television and PCS facilities using a "remote antenna" system was completed, and collaboration began with the Nexus company to construct the necessary equipment. The remote (or distributed) antenna concept is an extremely attractive technique for introducing wide area PCS service in an economic fashion by combining PCS and cable TV infrastructure. Under this approach, the expense of a wide area PCS system is minimized by centralizing much of its hardware at a cable head end and employing cable facilities to inexpensively extend the coverage throughout the system's franchise area.

Additionally, the possibility of integrating cable TV and PCS systems by employing commercially available cable data modems was investigated. Following a laboratory assessment of one particular modem (ISC-Datacom Model 2032), plans were made to construct digital PCS "back haul" channels on the Quantum cable system, and the equipment necessary for this test was ordered from ISC-Datacom.

C. Spring 1992

The first set of extensive propagation tests were conducted in St. Petersburg, Florida. In addition, experimentation with two different means of integrating cable and PCS infrastructure -- remote antennas and digital transport carriers -- were conducted using cable television systems in St. Petersburg, Florida, and New York City, respectively.

1. Propagation Measurements

Measurements of 2 GHz path loss were made at five different locations in St. Petersburg, Florida. A complex measurement procedure was employed to ensure that a complete profile of signal strength statistics was compiled at each measurement location. In addition to producing a set of statistics which will be used in the development of predictive models of PCS coverage and interference, two potentially significant inferences were drawn from an analysis of the measurement data:

(1) Except for paths which have obstructions, the rate at which the strength of the 2 GHz signals diminished was significantly less than that generally assumed in the design of cellular systems.

(2) An acceleration of the rate at which signal strength diminishes was observed for distances beyond a certain "break point." Because of its importance in the control of interference in PCS systems, further examination of this particular phenomenon was suggested in the next round of propagation tests.

If borne out in further testing and actual field experience, these effects could be used to simplify and make more economic PCS infrastructure.

2. Remote Antenna Systems

The St. Petersburg trial involved a test of the remote antenna system concept. As far as can be ascertained, this was the first test of the concept in the United States and the first test anywhere using live, fiber/coax cable facilities. The equipment used, while based on a design that had been developed jointly by Rogers Cablevision, Ltd. and Nexus Engineering, was constructed by Nexus especially for Time Warner and operates with CT-2 PCS equipment. Laboratory testing and initial field trials were a collaborative effort involving both Nexus and Time Warner personnel.

In brief, the remote antenna system consists of two components: a CT-2 base station/CATV plant interface (a "remote antenna signal processor" or RASP), and a low power repeater that is installed in the field (a "remote antenna driver" or RAD). Both units translate the time division duplex (TDD) 864-868 MHz

RF access channel into two separate frequency channels corresponding to the upstream and downstream cable channels.[4]

The successful demonstration of a PCS remote antenna system using operational cable television facilities highlighted the promise of this technology in deploying ubiquitous PCS service economically and led to the following important conclusions:

1. The remote antenna concept works. The coverage of the CT-2 base station was effectively channeled to a distant region of the cable plant through fiber trunk and coaxial cable, and several telephone calls were completed.

2. Cable architectures that are predominantly fiber exhibit many characteristics favorable to remote antenna performance, as compared to traditional coaxial cable systems. Among these characteristics are resistance to potentially interfering ingress signals and the existence of far fewer active and passive devices in the transmission path which can degrade and disrupt service.

3. Because of propagation delay which can be encountered over lengthy cable circuits, time division duplex systems (such as CT-2) may be more difficult to design, construct and operate than frequency division duplex schemes. Because a number of PCS system proponents continue to employ TDD, however, Time Warner intends to examine ways to improve the performance of TDD remote antenna systems in future experiments.

4. Several technical issues have been identified as requiring further study, including propagation delay characteristics of active and passive system components; the performance effects of different signal level configurations; and network capacity and

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[4] The base-to-handset channel is converted in frequency to approximately 490 MHz and delivered over the "downstream" portion of the cable plant to a radio repeater that establishes the off-air link with the handset. The handset-to-base channel is converted in frequency to the 5-30 MHz sub-low band and delivered over the "upstream" portion of the cable plant.

performance of using sub-low band frequencies (5-30 MHz).

3. Digital Transport Carrier Tests

The second experiment with PCS/Cable TV integration involved the use of digital "carriers," modulated onto upstream and downstream cable TV spectrum, as "back-haul" channels for full function PCS base stations. Under this approach, analog telephone voice signals are converted into digital signals, (possibly multiplexed together in some fashion and added to other digital communications and control signals) and modulated onto RF carriers of suitable frequency. Time Warner views this scheme as potentially attractive because CATV-based digital carriers could offer cost-effective transport capacity between a cable head end (which might be logically connected to a switching office) and full function PCS base stations.

As indicated above, the test set up employed commercially available cable modems and CT-2 PCS equipment, and the tests were performed using Time Warner's new 150 channel Quantum cable system which serves portions of Queens, New York. The unique Quantum architecture is the world's first commercially operational 1 GHz cable television system. It employs fiber trunks which fan out from a single head end in a star configuration to feed a series of neighborhood nodes. The nodes are linked to subscribers through a coaxial cable distribution network.

A total of five different system configurations were investigated.[5] Based on the overall results of these tests, it was concluded that cable-based digital transport carrier ("DTC") circuits are a very promising approach for at least partially meeting PCS infrastructures requirements. Several technical matters were identified for further study, however, including:

1. The extent to which frequency and phase response of both active and passive CATV elements can affect digital transmission quality;

2. The effect of adjacent channels on digital transmission quality;

3. The effect of absolute and relative (to video levels) digital carrier signal level on video and telecommunications channel performance;

4. The appropriate upstream and downstream frequency allocation arrangements; and

5. The effect of ingress, if any, to DTC transmission quality.

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5 In the initial test configuration, the two modem units were connected directly back-to-back through a short length of RG-6 coaxial cable and a step attenuator. This test set up was used to familiarize trial personnel with the equipment, ensure proper operation and program the units appropriately. The second test configuration connected the ISC Datacom equipment over a 14 km fiber optic test bed link that also carried multiple video channels. In a third configuration, the two codec/modems were linked over the coaxial cable TV system used within the Brooklyn/Queens headquarters office building. A fourth configuration had the remote codec/modem installed at a system test point, and a fifth test configuration had the remote unit installed at a subscriber's residence.

III. SUMMARY OF EXPERIMENTAL WORK CONDUCTED THIS QUARTER

A. Propagation Tests

During this quarter, the third and final phase of propagation testing was completed. In this stage, both path loss data and time delay characteristics of various frequency bands were collected using a broadband signal source (i.e., a "channel sounder").

1. Time Delay Measurements

Of all the technical attributes of a radio frequency channel, its time delay profile -- or delay spread -- may be the most critical determinant of digital system performance. Delay spread is caused by multiple signal reflections -- the same phenomenon which causes television "ghosts" and the fading of FM broadcast reception in an automobile ("picket fencing"). Delay spread affects different modulation schemes in different ways,[6] may be less severe under certain system conditions, and can be combated through a variety of techniques. In a digital telecommunications system, however, uncompensated delay spread can prevent a call from being set up, result in the sudden

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[6] For example, very wide band systems may not be as affected by some ranges of delay spread as narrow band systems. On the other hand, wide band systems may exhibit some other disadvantages not common to narrow band designs.

obliteration of a telephone call or introduce a large number of errors in a data circuit.

Therefore, Time Warner believes that the specification of delay spread is likely to be one of the key starting points in the design of a PCS system. The techniques used to compensate for delay spread all impose some price, however, especially on subscriber equipment.[7] Therefore, critical to an understanding of the value of these techniques, as well as the tradeoffs presented by different radio access technologies, system designs and applications, is an accurate description of the statistics of delay spread in various environments.

Delay spread has been a traditional channel metric in the cellular service,[8] but its effects in other frequency bands have only recently received serious attention. Although other field studies of the phenomenon had been conducted, Time Warner's exhaustive research on the topic, conducted in what many consider to be the world's worst mobile environment -- New York City, represents a major contribution in this area.

Clearly, therefore, a significant value of the attached report is in the ability it offers to analyze individually

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[7] Indeed, the cost of including equalizers which meet the European digital cellular GSM standard is said to be a major contributor to the high price of subscriber handsets.

[8] See, T.S. Rappaport, S.Y. Seidel, and R. Singh, "900 MHz Multipath Propagation Measurements for U.S. Digital Cellular Radiotelephone," IEEE Transactions on Vehicular Technology, Vol. 39, No. 2, May 1990, pp.132-139.

different combinations of access technology, system architecture and service offerings. Certain important inferences of a more general nature can also be drawn from the analysis:[9]

(1) Delay spread for microcell systems in the 1850-1990 MHz band would not appear to be any more severe than for similarly-sized systems operating in the existing cellular band. While the delay data reported for individual test sites exhibit some expected variation among frequencies, no significant difference in the statistical distribution of delay across measuring sites and locations between the three bands measured was observed.

(2) The relatively small value of the maximum observed delay spread (350 ns) suggests that 2 GHz microcell systems could support reasonably high data rates for voice quality communications.

If these results continue to hold true, it is not unreasonable to expect that high quality, relatively inexpensive PCS subscriber equipment can be manufactured.

2. Path Loss Measurements

Because the strength of a signal determines the extent of both coverage within a cell and interference to adjacent cells, a tool which can reliably predict signal strength at any location will be extremely important in the design of efficient, high

[9] Data was collected at 7 test sites in Manhattan and Queens, New York City. At each test location, measurements were made at 20 - 40+ test locations in three different frequency bands (915 MHz, 1.9 GHz, and 2.4 GHz). The analysis of the test data was performed by Scott Y. Seidel and Prof. Theodore S. Rappaport of TSR Technologies (both Seidel and Prof. Rappaport are associated with the Mobile & Portable Radio Research Group of Virginia Polytechnic Institute and State University at Blacksburg, Virginia.)

capacity, high quality PCS systems. The measurement data gathered to characterize delay spread were also used to assess signal strength loss at each individual location. Two potentially significant inferences may be drawn from these data:

(1) The rate at which signal strengths diminish may accelerate at distances beyond a certain "break point," as was observed in Time Warner's earlier propagation tests and has been reported in the literature. The existence of such a phenomenon could be a potentially important consideration for interference control in a mature PCS system.

(2) While variations (caused by local shadowing, perhaps) existed from one measurement site to another, the report concludes that there was little statistical difference between cellular and PCS frequencies in the rate at which signal strengths diminished. This conclusion suggests that the experience gained at 800 MHz may be more directly transferable to 1.8 MHz systems than had been anticipated.

These inferences reconfirm the observations made following the earlier study that the propagation characteristics of 2 GHz frequencies may actually contribute positively to the design of cost-effective PCS infrastructure.

Perhaps an even more important output of this study, however, is the statistical model that was developed which relates coverage probability to particular propagation environments. This model can be used to design a system with microcellular coverages that are much more predictable (and, therefore, more cost-effective and higher quality) than systems where coverage areas are selected arbitrarily.

B. PCS/Cable Integration Studies

In addition to conducting fundamental propagation research, Time Warner continues to conduct trials to assess the feasibility of using cable TV plant as infrastructure for PCS systems. As discussed above, reports on initial tests of two different system designs -- remote antennas and digital transport carrier circuits -- were filed with the Commission in May 1992. Expanded tests of both approaches are underway and several additional tests are planned for the future.

1. Remote Antenna Tests

Further tests of the remote antenna system are being conducted on the St. Petersburg, Florida, cable plant.[10] Time Warner's first phase of experimentation demonstrated the capabilities of the system by conducting communications through a single remote antenna and alerted the company to several aspects of remote antenna operation deserving of further study. Prominent among these were the effects of cable and fiber delay on system performance and the potential for leakage and signal ingress.

These and other factors are being studied in the second experimental phase now underway in St. Petersburg, and the results of these tests will be filed with the Commission at their

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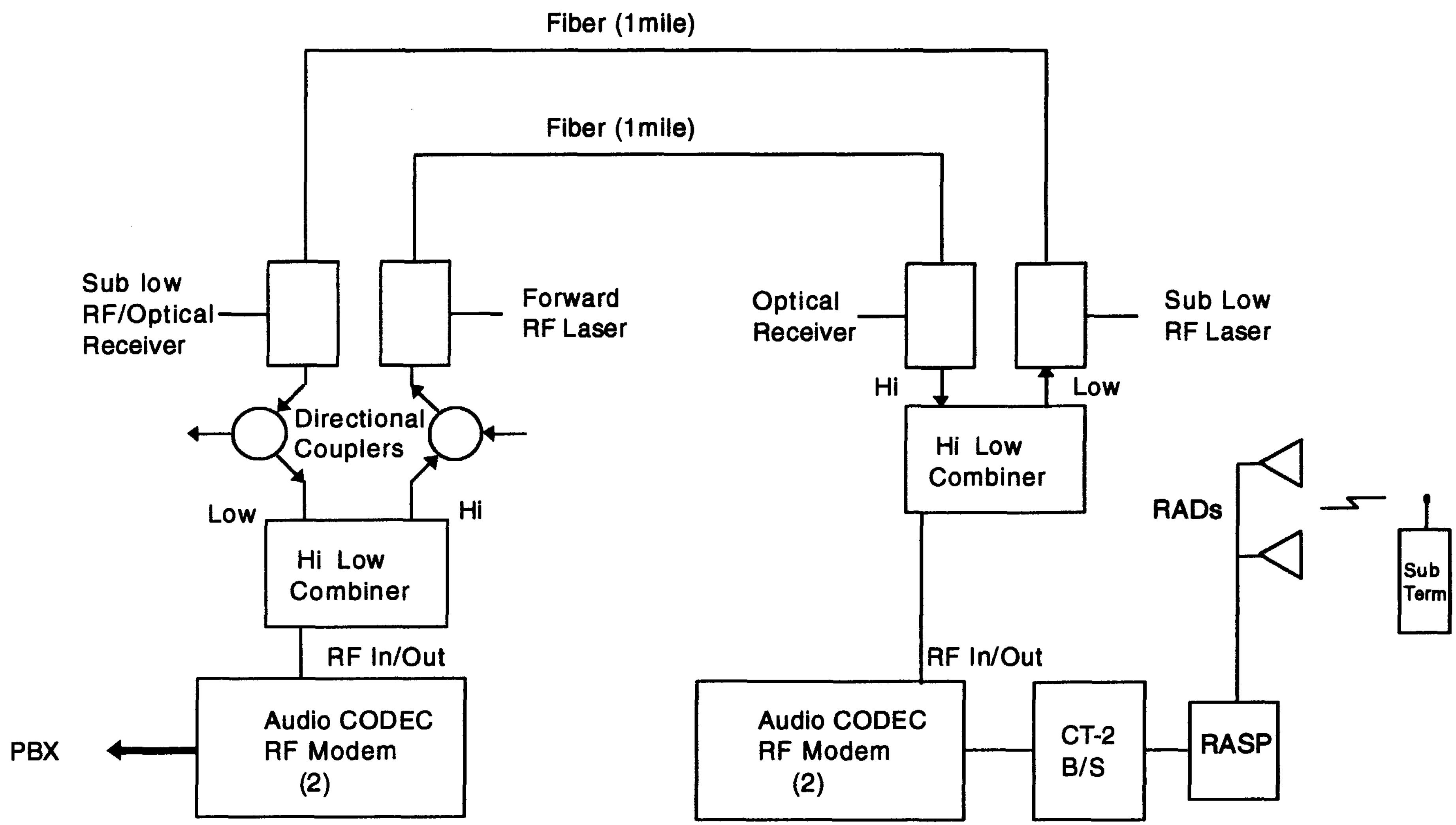
[10] As stated previously, the remote antenna system employed in these experiments is a prototype unit constructed by the Nexus company expressly for Time Warner's St. Petersburg trial. Nexus and Time Warner collaborated on the lab testing and initial field tests of this equipment.

conclusion. The design under test is shown in Figure 1. It is a hybrid of the two system concepts Time Warner has been testing and consists of a duplex digital transport carrier circuit between the PSTN interface at the cable TV headend and a PCS base station/remote antenna signal processing unit ("RASP") that are installed at a fiber node approximately one mile into the cable plant. The RASP, in turn, feeds one or more associated remote antenna drivers ("RADs") over a common coaxial circuit. In addition to replicating the expected configuration of a more mature PCS/cable system, the hybrid test scheme allows Time Warner to disaggregate the effects due to cable plant delay and study more closely other aspects of cable RAD performance such as voice quality, call set up/tear down problems and the effect of traffic loading.

Moreover, in tests involving more than one RAD, hand off between the units will be examined, with both pedestrian and vehicular speeds being tested. This feature originally was demonstrated by Rogers in Canada, and subsequently by others. Nevertheless, the quality of handoff appears to be a function of many factors which, based on Time Warner's research, have yet to be fully quantified. Consequently, the company intends to investigate handoff and contribute its test results to the growing body of technical knowledge concerning remote antenna systems.

Figure 1

Remote Antenna Test Configuration



Examination of two other system parameters is also planned. The first is signal leakage, especially on the downstream path. Inasmuch as the remote antenna system performs a frequency conversion, depending upon the degree of filtering present on either end of the system, it is conceivable that energy from up-converted television signals could be emitted from the RAD. Therefore, it would be useful to quantify the conversion gain/loss of this process in an operational cable plant. To the extent signal leakage appears to be a potential problem, the results of this examination can be used to refine the system hardware (i.e., filters) or cable frequency allocation.

The second parameter of interest is dynamic range. This factor specifies the maximum difference in power level received at the RAD which may exist between two subscriber terminals before performance degrades significantly. The extent to which power levels will vary widely is not well known. In order to predict the extent to which performance degradation might actually occur, it is necessary to examine the performance of an operational remote antenna when it is presented with two (or more) signals that differ widely in signal strength and quantify the limits of acceptable performance. To the extent performance problems are anticipated due to the results of this test, changes in RAD circuit design might be called for.

2. Tests of Digital Transport Carrier Circuits

"Digital transport carrier" circuit tests have also been conducted this quarter, and additional tests are planned to commence soon. As reported previously, these digital channels essentially mimicked the means a cable plant might be used as "back haul" facilities in a PCS system and were used to link a PCS subscriber base station to the telephone network interface at the cable system's headend.

a. 1850 MHz Demonstration

A demonstration 1850 MHz PCS digital transport carrier system was constructed by Time Warner for exhibition (pursuant to FCC Special Temporary Authority) at a recent display of PCS technologies and systems in the Foyer of the Rayburn House Office Building on Capitol Hill. The cable TV portion of the demonstration system consisted of a single channel "headend" (video tape player, modulator and associated combining networks), "outside plant" (1000 feet of RG-6 coaxial cable) and a subscriber television receiver.

The cable TV equipment was supplemented with radio frequency modems which were used to establish a digital carrier transport circuit between the PSTN and a six channel Omnipoint DS-1900 1850 MHz TDMA/CDMA PCS public base station. Many telephone calls were successfully completed using the demonstration system.

Construction and operation of this system provided Time Warner with an early opportunity to obtain operating experience with 1850 MHz equipment. As discussed below, this equipment will soon be installed in the company's Quantum cable system.

b. First Pacific Network System Integration

Final preparations now are being made to conduct further tests of the digital carrier concept on the Quantum system. As illustrated in Figure 2, in addition to employing the new Omnipoint 1850 MHz equipment, these tests will also use a digital transmission scheme different from that employed previously.[11]

Digital transport carrier circuits will be provided from a First Pacific Networks ("FPN") "Personal Xchange" digital transmission system. The FPN system is designed as a digital subscriber line carrier system over cable facilities, and Time Warner has installed this equipment to test it in this mode. However, because the digital trunks can also be used to link a PCS base station to the telephone network, this configuration will also be employed to feed a six channel PCS base station. To the best of Time Warner's knowledge, this test will represent the first time the FPN system has been configured in this manner, at least over an active U.S. cable system.

Initially, the PCS system will be operated within the confines of the Brooklyn/Queens business offices. This plan will allow for a complete technical evaluation of the system and

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[11] As discussed above, the initial tests of digital transport carrier circuits in Quantum employed CT-2 PCS equipment.